PATENT SPECIFICATION (11) 1 268 397

DRAWINGS ATTACHED

1 268 397

(21) Application No. 30099/69 (22) Filed 13 June 1969
(23) Complete Specification filed 14 Sept. 1970
(45) Complete Specification published 29 March 1972
(51) International Classification B 01 d 13/00
(52) Index at acceptance
B1X 6

(72) Inventor JOHN DENNIS USHER

(54) IMPROVEMENTS IN OR RELATING TO THE CONCENTRATION OF LIQUIDS

(71) We, THE A.P.V. COMPANY LIMITED, a British Company, of Manor Royal, Crawley, Sussex, do hereby declare the invention, for which we pray that a patent may be granted to us, and the method by which it is to be performed, to be particularly described in and by the following statement:—

THIS INVENTION relates to the concentration of liquids and more particularly to apparatus for concentrating liquids by a process of reverse osmosis.

The principle of reverse osmosis is based on the application to a solution of a pressure higher than the osmotic pressure so that the solvent is forced through a permeable membrane leaving behind a more concentrated solution. The concentration of heat labile liquids by reverse osmosis has the advantage that the operation takes place at ambient temperature so that no deterioration of product quality can occur because of thermal degradation. In any apparatus designed for practicing this process industrially the following requirements must be borne in mind:—

1. The equipment must be capable of withstanding the high pressures associated with reverse osmosis which may amount to 1,000 to 2,000 pounds per square inch (say 70 to 140 kg per square cm.).
2. Because of the separation of solvents and solute which occurs at the membrane surface, polarisation occurs due to the localised concentration of liquid which reduces the effectiveness of the membrane. It is therefore necessary to induce liquid turbulence at the membrane surface in order to prevent this polarisation taking place.
3. The concentration ratio expressed as the ratio of total solids in the concentrated product to per centage of total solids in the feed is limited in any one stage of reverse osmosis so that to achive high concentration ratios it is necessary for two or more stages to operate in series.
4. It is necessary for the membrane to be backed by a porous material through which the solvent can exude and in order to minimise the risk of the fragile membrane being broken, it is common practice to interpose a soft material such as a filter paper between the membrane and the porous backing.
5. Because of the fragility of the membrane and the complexity of the assembly it is necessary for operational reasons for the plant to be designed in a way that it can easily be assembled and dismantled for the purposes of membrane replacement.

It is an object of the invention to provide apparatus meeting the criteria set forth.

In accordance with the invention, apparatus for concentrating feed liquids by reverse osmosis comprises a plurality of reverse osmosis units mounted in a frame, each unit comprising a porous element for removing solvent withdrawn from the feed liquid, a membrane at each side of the porous element, feed liquid flow passages defined between the membranes and gasketed plate elements mounted in the frame, at least one sealed liquid flow port through the porous element to interconnect the flow passages on either side of the porous element, the plate elements having apertures for interconnecting the adjacent flow passages in one unit with a flow passage in an adjacent unit and each plate element having formations thereon for inducing turbulence to prevent polarisation at the membrane surface.

Each plate element may be provided with a pair of apertures aligned with corresponding apertures in the other plate elements to define inlet or outlet ports for

the flow passages. A group of flow passages may be arranged in parallel between the inlet and outlet ports of the associated plate elements and a succeeding group of flow passages may be in series with the said group and also in parallel with each other across the associated inlet and outlet ports.

The porous element may have a soft material, such as filter paper, inserted between itself and the membrane on each side.

The frame used may comprise a top carrying bar and a lower guide bar for the plate elements and units, the bars extending between a head unit and an end support, and the assembly of plate elements and reverse osmosis units may be clamped together between the head unit and a clamping unit mounted on the top and bottom bars and connected to the head unit by tie bars.

The invention will be further described with reference to Figures 1 to 5 and 8 to 10 of the drawings accompanying the Provisional Specification in which:—

Figure 1 is a diagrammatic elevation of a form of frame suitable for holding a preformed form of reverse osmosis apparatus according to the invention;

Figure 2 is an exploded, diagrammatic perspective view showing some details of part of the apparatus used in Figure 1;

Figure 3 is a partial section on the line III-III of Figure 2 showing the structure of the reverse osmosis units;

Figure 4 is a partial section on the line IV-IV of Figure 2 showing further features of the structure of the reverse osmosis units;

Figure 5 is a scrap view of a detail of two adjacent units:

Figure 8 is an enlarged elevational view of one corner of a plate showing a support and sealing detail;

Figure 9 is a section on the line IX-IX of Figure 8 also including a portion of an adjacent reverse osmosis unit;

and

Figure 10 is a diagram showing one possible flow arrangement.

Figure 1 shows a typical frame which may be used for assembly of the apparatus. It comprises a head member 1, an end support 2, a top bar 3, a bottom bar 4 and a clamp member 5 which is slidable on the top and bottom bars. A pack, generally designated 6, of plates and reverse osmosis units is clamped between the clamp member 5 and the head member 1, and the closed position of the frame is maintained by tie bars 7 extending between the head member 1 and the clamp member 5 outside the pack 6. A liquid connection 8 is provided in the head member and a liquid connection 9 is provided on the clamp member. A tray 10 is located beneath the pack, and is provided with an outlet sump 11. This tray 10 collects the solvent which is forced out of the reverse osmosis unit to the outside of the pack 6, where it falls by gravity into the tray and is led away through the sump 11.

Figure 2 shows how the pack 6 includes plates 12 provided with apertures 13 and 13*a* aligned with corresponding aperatures in other plates, and it can be seen from Figure 3 in particular how each pair of adjacent plates 12 define between them a reverse osmosis unit. A porous element 14 has on either side of it a soft supporting sheet 15, and beyond that, on either side there is a permeable membrane 16. These five elements are mounted together in supports shown in somewhat exaggerated form at 17 in Figure 2 and the assembly, unit or module comprising these elements is clipped together by spring clips shown at 18 which engage on lugs on the supports, the lugs extending beyond the boundary of the plates 12. Figure 5 illustrates how the spring clips 18 on alternate units or modules are attached to lugs extending in different directions so as to prevent the clips 18 fouling one another when the pack of units and plates is clamped together.

The plates 12 are preferably made of stainless steel or other corrosion resistant material and are provided with peripheral gaskets 19 held in position by strips 20 spot welded or otherwise attached to the plate. It can also be seen from Figure 2 that the plates 12 are provided with flow controlling baffles 21 which provide for a serpentine flow of the liquid over the plates between the aperatures 13 and 13*a* and also the plates are provided with undulations or corrugations 22 which extend quite close to the membranes 16 on either side of the plate so that as the liquid flows across the corrugations 22, considerable turbulence is induced and polarisation at the membrane surface is substantially eliminated. The gaskets 19, backed by the strip 20, seal the space between the plate and the unit against the internal pressure.

In the preferred arrangement illustrated, the reverse osmosis units or modules are also provided with apertures 23 and 24 in alignment with the apertures 13 and 13*a* in the plates. In order to prevent the solution by-passing the membrane and passing straight into the porous element 14, it is necessary to seal the membrane around the periphery of the apertures 23 and 24. This may be achieved by heat sealing the membranes on either side of the porous plates together around the aperture, as is shown at 25 in Figure 4.

As an alternative to heat sealing around the port, leakage at this point may be

prevented by firmly compressing the membrane 16 against the soft supporting sheet 15 around the port periphery.

Such a construction is shown in Figures 8 and 9. In this arrangement, two rings 30 are welded, one to either side of the plate 12, around the periphery of the aperture 13 (or 13*a*). These rings have a series of radial slots 31 which provide communication between the aperture and the flow passages, and the upper surfaces of these rings cooperate with gaskets 32 which pass over the edges of the apertures in the reverse osmosis units. These gaskets 32 seal the membrane against cross leakage, and the rings 31 compress them to ensure that the seal is maintained in operation.

Figure 10 illustrates the flow arrangement in a typical two-stage assembly. The feed liquid is fed in at the point F1, which may for instance be constituted by the connection 8 which is aligned with the apertures 13 and 23. A series of flow passages in series are illustrated at 34, and the aperatures 13*a* and 24 in the associated plates and units are illustrated at F2 to form a discharge port for the first stage. This is aligned with the feed port for the second stage, and the ports 13 and 23 then constitute a discharge port for the second stage which leads to the output connection P1, which may be constituted by the connection 9 of Figure 1. It can be seen that this type of arrangement is achieved by omitting a port, here shown as the port 13 or 23 in the fifth plate. The solvent which is extracted by the reverse osmosis flows into and through the porous elements in the unit, and is collected on the outside of the unit in the tray 10.

It will be appreciated that while Figure 10 shows only a two-stage system, any number of stages could be arranged in series, with the possible interposition of further pumps to maintain the high pressures necessary for the reverse osmosis process.

Further, it is possible by suitable blanking off of ports to arrange for a large number of flow passages to be arranged in series, without any parallel arrangement being provided. The only sealing necessary is in the passage through the apertures to ensure that the feed liquid cannot short circuit into the porous members.

Various other modifications may be made within the scope of the invention.

WHAT WE CLAIM IS:—

1. Apparatus for concentrating feed liquids by reverse osmosis, comprising a plurality of reverse osmosis units mounted in a frame, each unit comprising a porous element for removing solvent withdrawn from the feed liquid, a membrane at each side of the porous element, feed liquid flow passages defined between the membranes and gasketed plate elements mounted in the frame, at least one sealed liquid flow port through the porous element to interconnect the flow passages on either side of the porous element, the plate elements having apertures for interconnecting the adjacent flow passages in one unit with a flow passage in an adjacent unit and each plate element having formations thereon for inducing turbulence to prevent polarisation at the membrane surface.

2. Apparatus as claimed in Claim 1, in which inlet and outlet ports for the units are defined by aligned apertures in the plates and units.

3. Apparatus as claimed in Claim 2, in which a group of flow passages are arranged in parallel between the inlet and outlet ports.

4. Apparatus as claimed in Claim 3, in which a further group of flow passages are in parallel with each other and in series with the said group of flow passages.

5. Apparatus as claimed in any of the preceding Claims, in which soft material, such as filter paper, is inserted between the porous elements and the membranes.

6. Apparatus as claimed in any of the preceding Claims, in which the frame comprises a top carrying bar and a lower guide bar for the plate elements and units, the bars extending between a head unit and an end support and the assembly of plate elements and reverse osmosis units being clamped together between the head unit and a clamping unit mounted on the top and bottom bars and connected to the head unit by tie bars.

7. Apparatus as claimed in any of the preceding Claims, in which the components of the units are mounted in supports which are clamped together.

8. Apparatus as claimed in Claim 7, in which the supports have lugs projecting beyond the perimeters of the plate elements and the lugs are secured together.

9. Apparatus as claimed in Claim 8, in which the lugs on adjacent units project at non-aligned locations.

10. Apparatus as claimed in any of the preceding Claims, in which the plate elements are provided with corrugations to induce turbulence.

11. Apparatus as claimed in any of the preceding Claims, in which the plate elements are provided with flow control baffles to constrain the liquid to follow a serpentine path along the flow passages.

12. Apparatus as claimed in any of the preceding Claims, in which the membranes on each side of porous elements are heat sealed together in the region of the flow ports through the porous elements.

13. Apparatus as claimed in any of

Claims 1 to 11, in which gasket elements are located in the flow ports through the porous elements and are compressed and located by pressure means on the plate elements.

14. Apparatus for connecting feed liquids by reverse osmosis, substantially as hereinbefore described with reference to Figures 1 to 5 and 8 to 10 of the drawings accompanying the Provisional Specification.

MARKS & CLERK
Chartered Patent Agents
57 & 58 Lincoln's Inn Fields,
London, WC2A 3LS
Agents for the applicant(s)

Printed for Her Majesty's Stationery Office by The Tweeddale Press Ltd., Berwick-upon-Tweed, 1972.
Published at the Patent Office, 25 Southampton Buildings, London WC2A 1AY from which copies may be obtained.

1268397 PROVISIONAL SPECIFICATION
3 SHEETS *This drawing is a reproduction of the Original on a reduced scale*
Sheet 1

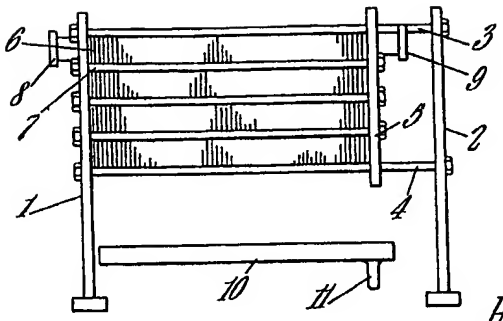

Fig.1.

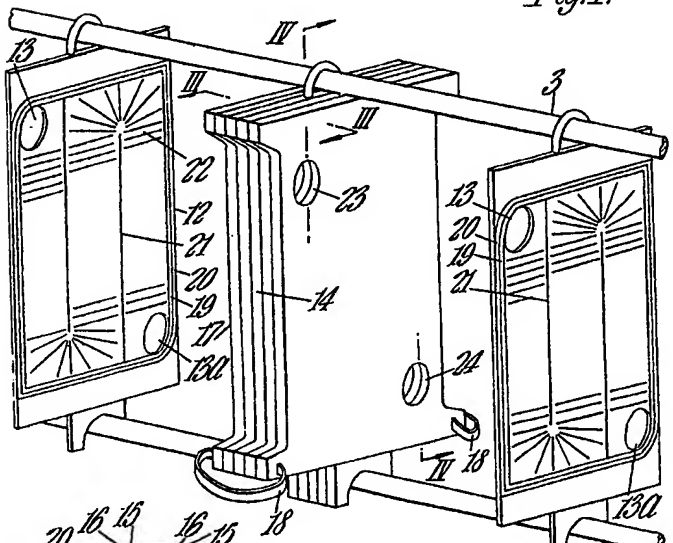

Fig. 2.

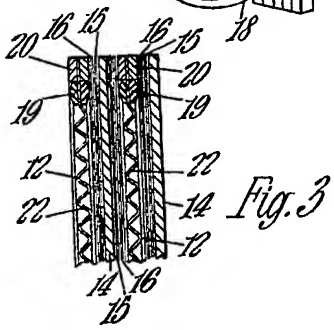

Fig. 3

1268397 PROVISIONAL SPECIFICATION
3 SHEETS *This drawing is a reproduction of the Original on a reduced scale*
Sheet 2

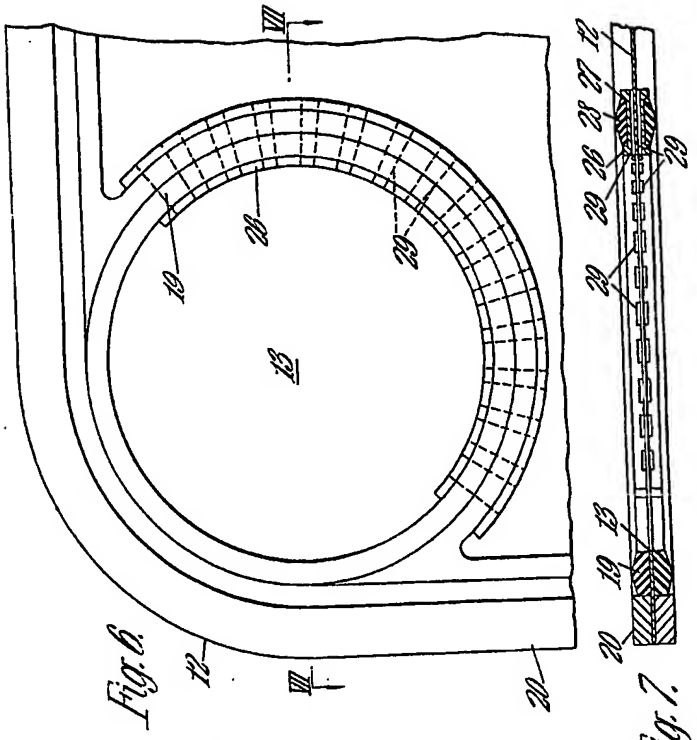

Fig. 6.

Fig. 7.

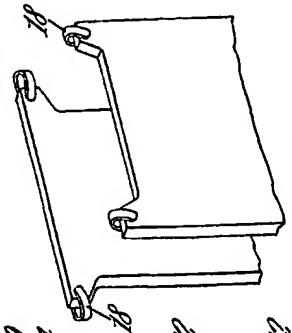

Fig. 5.

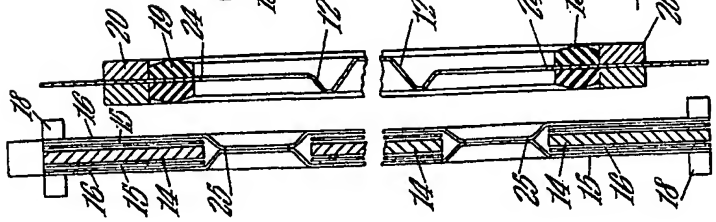

Fig. 4.

1268397 PROVISIONAL SPECIFICATION
3 SHEETS *This drawing is a reproduction of the Original on a reduced scale*
Sheet 3

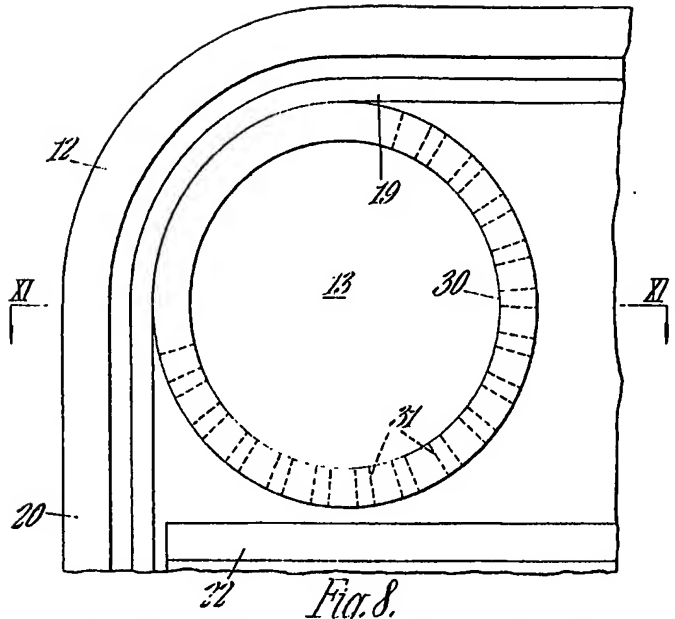

Fig. 8.

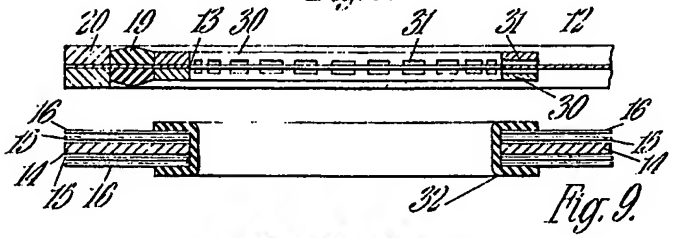

Fig. 9.

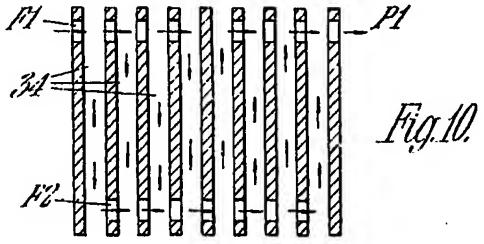

Fig. 10.